


2015 California Demand Response Potential Study

Updated Phase 1 Results

18 August 2016

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Presentation Overview

- Executive summary of results
- Background on Phase 1 model update
- Updated Phase 1 results
  - 2020 DR Potential
  - 2025 DR Potential
- Updated model inputs
  - LBNL-LOAD module
  - DRPATH & economic valuation modules

Executive Summary

- Phase 1 update estimates 4.2 GW of Resource Adequacy (RA) DR under a 2025, *1-in-2 weather, mid-demand scenario, mid-AAEE, Rate Mix #3 reference case*
  - Phase 1 re-run results in ~5.2 GW, including ~1 GW TOU load impacts

- Phase 1 update includes a range of 3 TOU/CPP* rate options that reduce need for peak capacity by approximately 1 GW under each option

***TOU = time-of-use; CPP = critical peak pricing**

Background: Phase 1 Update

- Stakeholder feedback on initial "frozen efficiency" assumption forecast suggested baseline should be revised to include 2015 IEPR mid-AAEE & no-AAEE load forecasts
- **Enhancements to model**:
  - Baseline forecast includes **2015 IEPR mid-AAEE*** & no-AAEE load forecasts
  - Additional load profile data to increase time series coverage
  - Corrected 2014 customer demographic data that includes all customers
  - Refined & added permutations on TOU impact estimates to capture different rate mixes
  - Improved computational architecture to streamline large-scale analysis

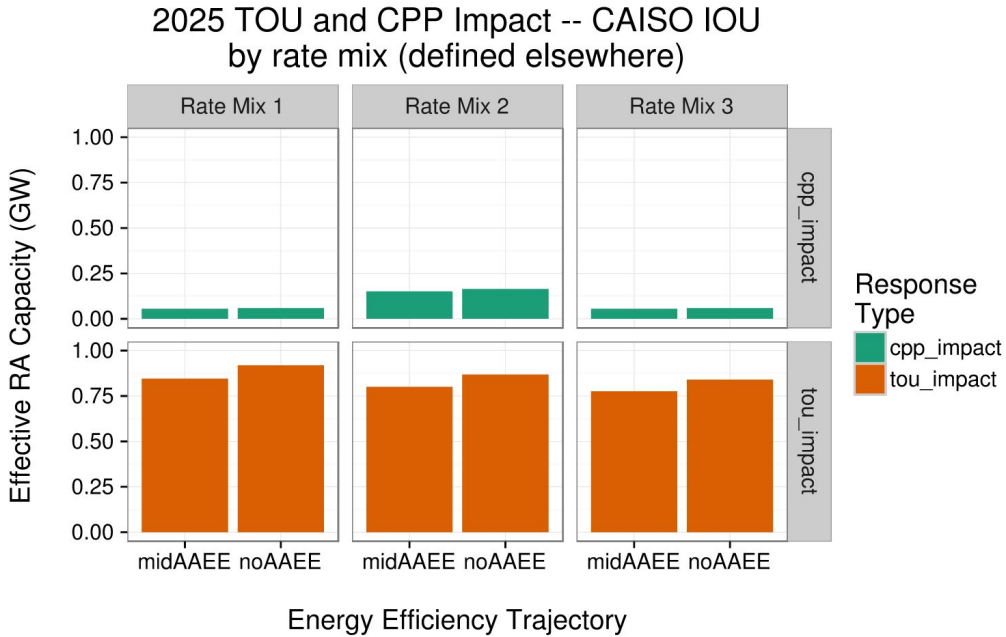
***Integrated Energy Policy Report, Additional Achievable Energy Efficiency**

Phase 1 Methodology: Changes in Inputs for Model Update

- Additional customer clusters
- Revised forecast includes more energy efficiency (EE)
- Revised EV cost data
- Added additional TOU & CPP load impacts
- Revenue adjustment for planning reserve margin
- Updated renewable resources and weather used for net load profile forecasts
- Revised end use lighting profiles by removing exterior lighting

Updated Phase 1 Results

2025 Load Modifying Resources: TOU/CPP *by* EE Scenarios & Rate Mix

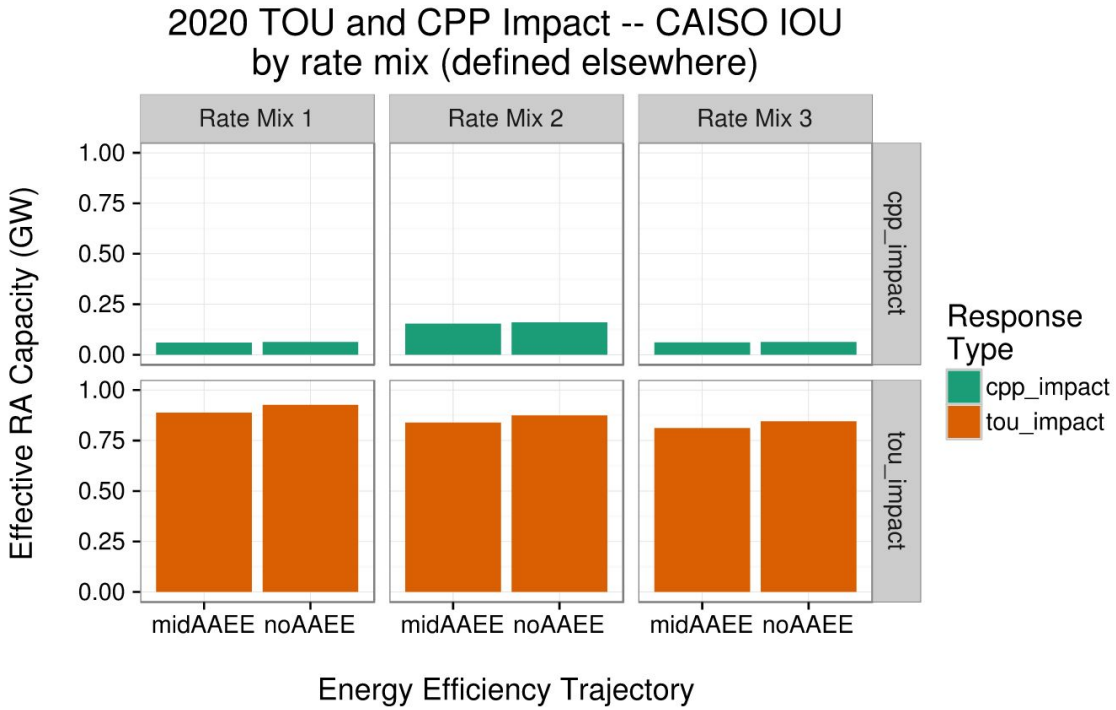


CPP						
	No AAEE			Mid AAAEE		
	rate_mix_1-CPP	rate_mix_2-CPP	rate_mix_3-CPP	rate_mix_1-CPP	rate_mix_2-CPP	rate_mix_3-CPP
Non-Residential	0.06	0.06	0.06	0.06	0.06	0.06
Residential	0.00	0.11	0.00	0.00	0.10	0.00
Total	0.06	0.16	0.06	0.06	0.15	0.06

TOU						
	No AAEE			Mid AAAEE		
	rate_mix_1-TOU	rate_mix_2-TOU	rate_mix_3-TOU	rate_mix_1-TOU	rate_mix_2-TOU	rate_mix_3-TOU
Non-Residential	0.62	0.62	0.62	0.59	0.59	0.59
Residential	0.30	0.25	0.23	0.26	0.22	0.19
Total	0.92	0.87	0.84	0.85	0.80	0.78

Note: Update shows lower TOU/CPP impacts than other studies, likely due to LBNL model using hourly impact estimates for *each hour* in 250 RA hours. Other studies used *average impacts* for each month.
Non-residential tariff is same in every rate mix.

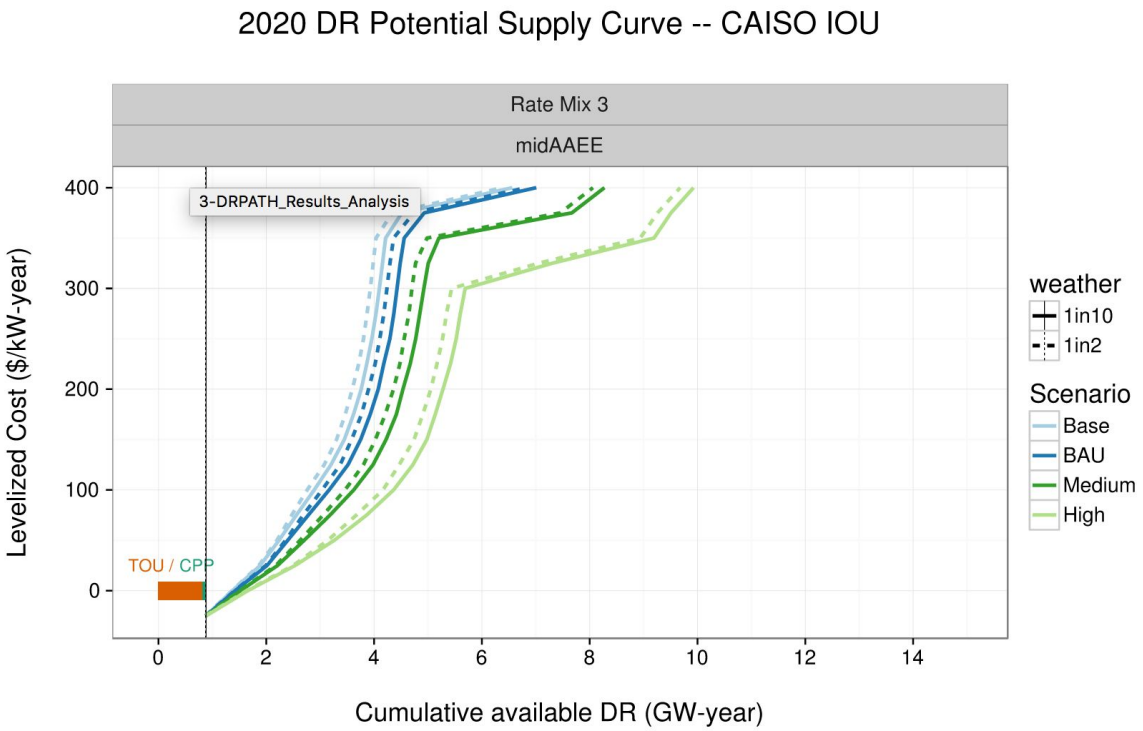
2020 Load Modifying Resources: TOU/CPP *by* EE Scenarios & Rate Mix



Note:

- These are same as 2025 estimates.
- **We impose enrollment rate estimates that kick in before 2020 & persist through duration of modeled time periods.**
- Estimates for load impacts are not different year-to-year.

2020 Demand Response Potential

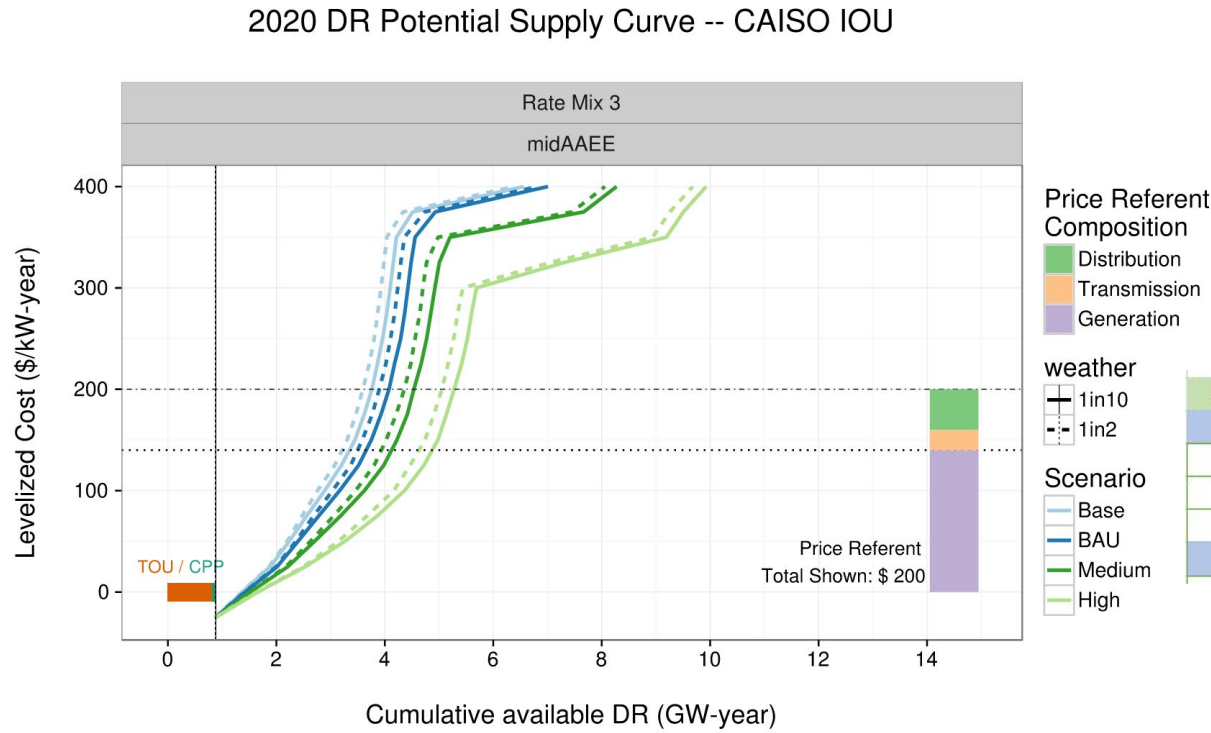


Note:

- DR has "negative cost" when revenue offsets full cost of DR (technology & soft costs).
- IOU refers to:
  - SDG&E
  - PG&E
  - SCE

2020 Demand Response Potential

With conventional price referent benchmark lines

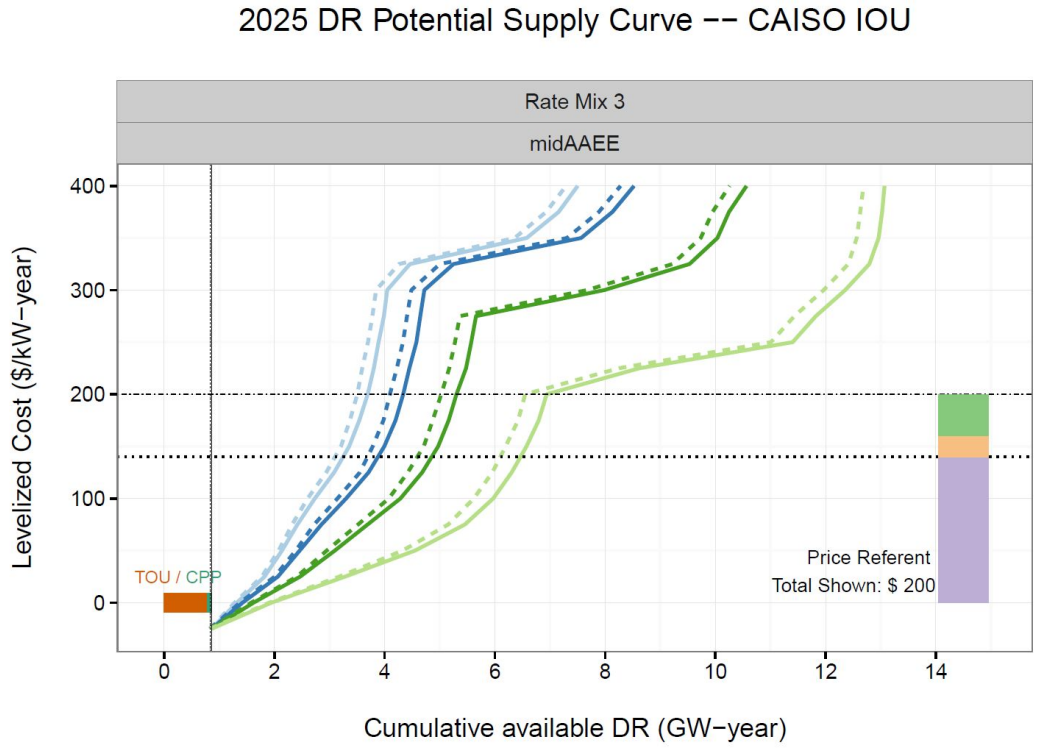


"Supply" DR for Peak Shed

Mid-AAEE, Rate mix 3, 1:2 weather, $200/kW/yr price referent				
Utility	**Base**	**BAU**	**Medium**	**High**
PG&E	1.3	1.5	1.7	2.0
SCE	1.2	1.4	1.6	1.9
SDG&E	0.1	0.1	0.2	0.2
Total	**2.6**	**3.0**	**3.5**	**4.1**

2025 Demand Response Potential

With conventional price referent benchmark lines

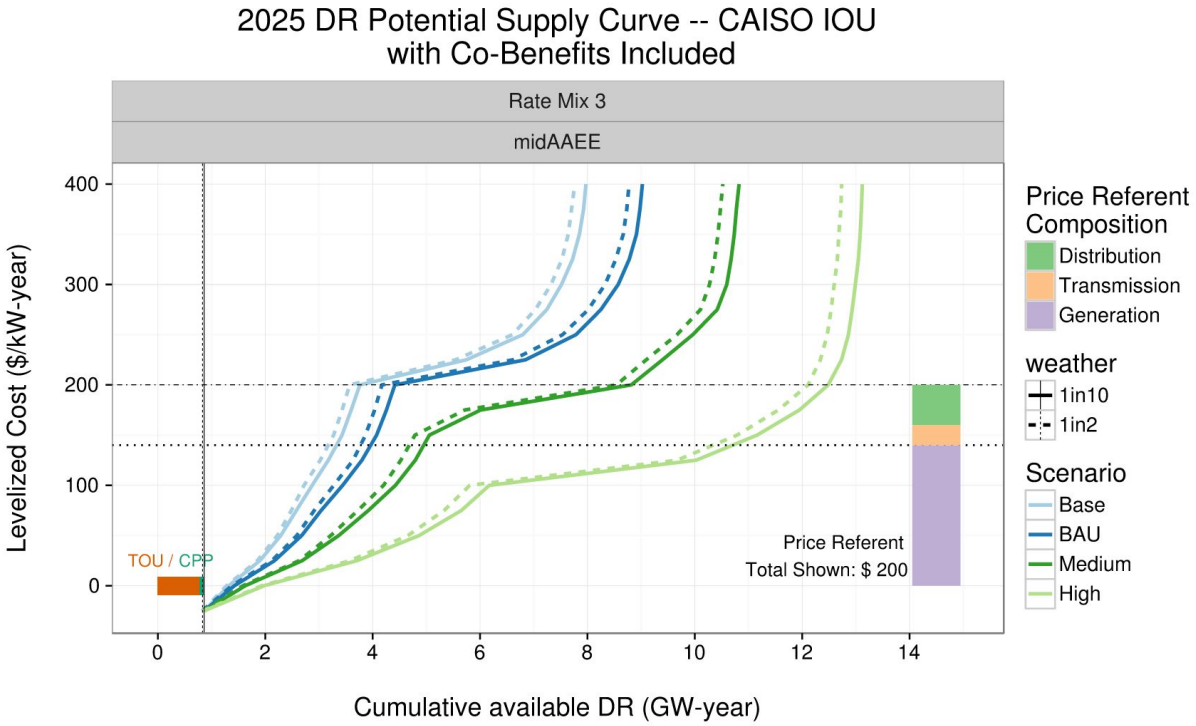


"Supply" DR for Peak Shed

Mid-AAEE, Rate mix 3, 1:2 weather, $200/kW/yr price referent				
Utility	**Base**	**BAU**	**Medium**	**High**
PG&E	1.3	1.6	2.0	2.8
SCE	1.2	1.5	1.9	2.6
SDG&E	0.1	0.2	0.2	0.3
Total	**2.7**	**3.3**	**4.2**	**5.7**

2025 Demand Response Potential

Including Possible Co-Benefits that Reduce DR Cost

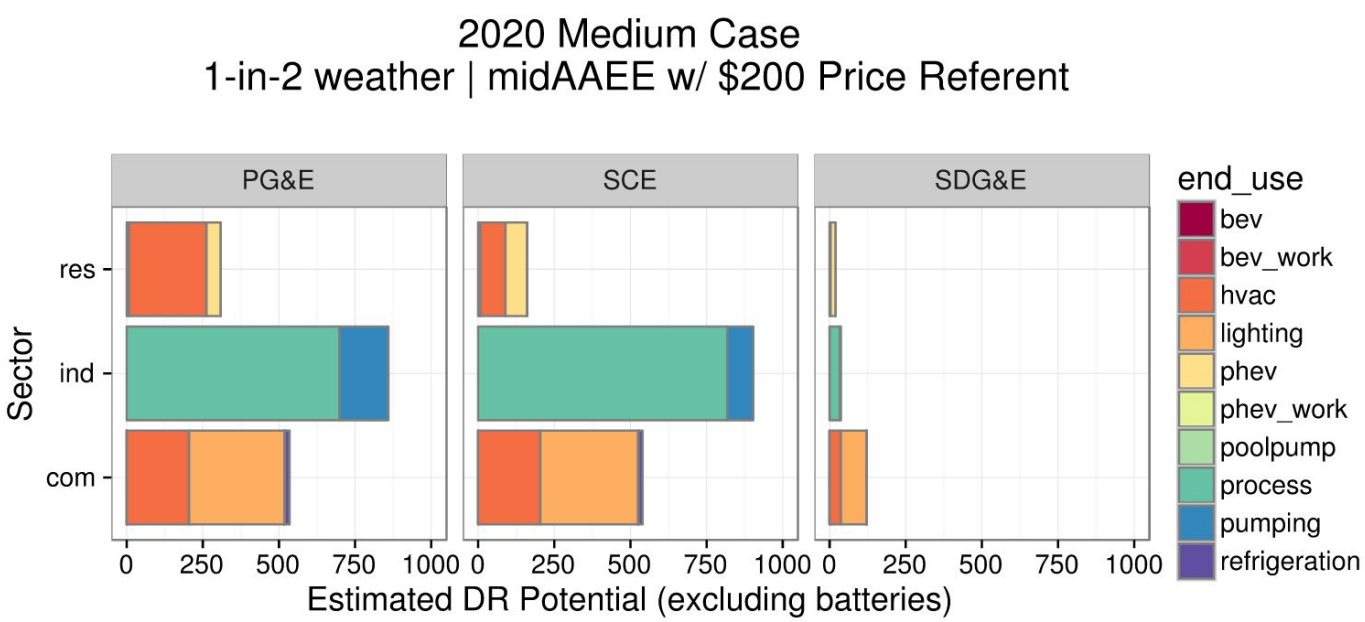


Note:

- On this & other plots that include note "**with Co-benefits Included**", we include preliminary set of DR co-benefits that reduce upfront DR resources' cost -- these are monetizable benefits from technology adoption like EE benefits that are linked with adopting DR in particular technology cases.
- **Phase 2: We will continue to explore & improve co-benefits' assumptions.**

End-Use & DR-Enabling Tech	Initial DR Technology Cost Reduction from Co-Benefit*
Comm'l & Residential HVAC (EMS & Smart Thermostat)	30%
Refrigerated Warehouses	30%
Batteries	50%
Comm'l & Residential BEV & PHEV Level 1 & 2 charging (Fleet & Public)	75%
Lighting (Luminaire-level & Zonal)	75%

Supply-Side Peak Shed DR | 2020



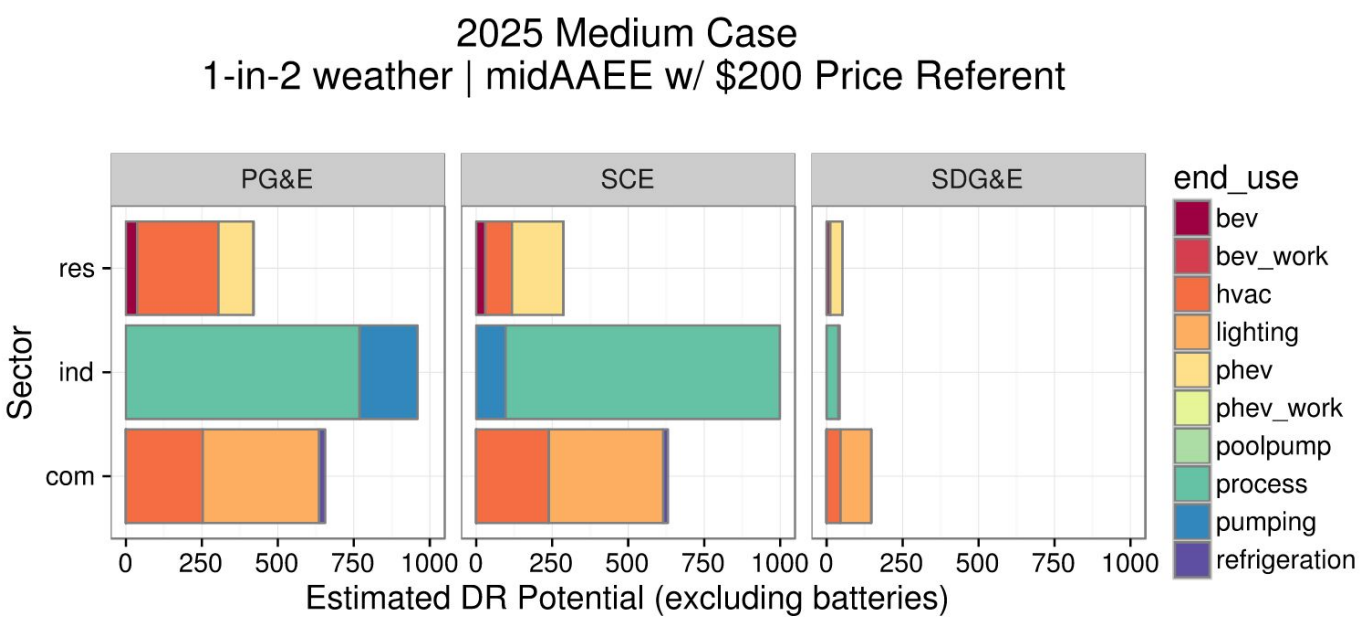
PG&E total: 1.7 GW SCE total: 1.6 GW SDG&E total: 0.18 GW

Total Medium Scenario: 3.5 GW

Total MW:

sector	end_use	tot
com	battery	0
com	bev	0
com	bev_work	0
com	hvac	446
com	lighting	721
com	phev	0
com	phev_work	0
com	refrigeration	30
ind	battery	0
ind	process	1551
ind	pumping	248
res	battery	0
res	bev	18
res	hvac	337
res	phev	135
res	poolpump	0

Supply-Side Peak Shed DR | 2025



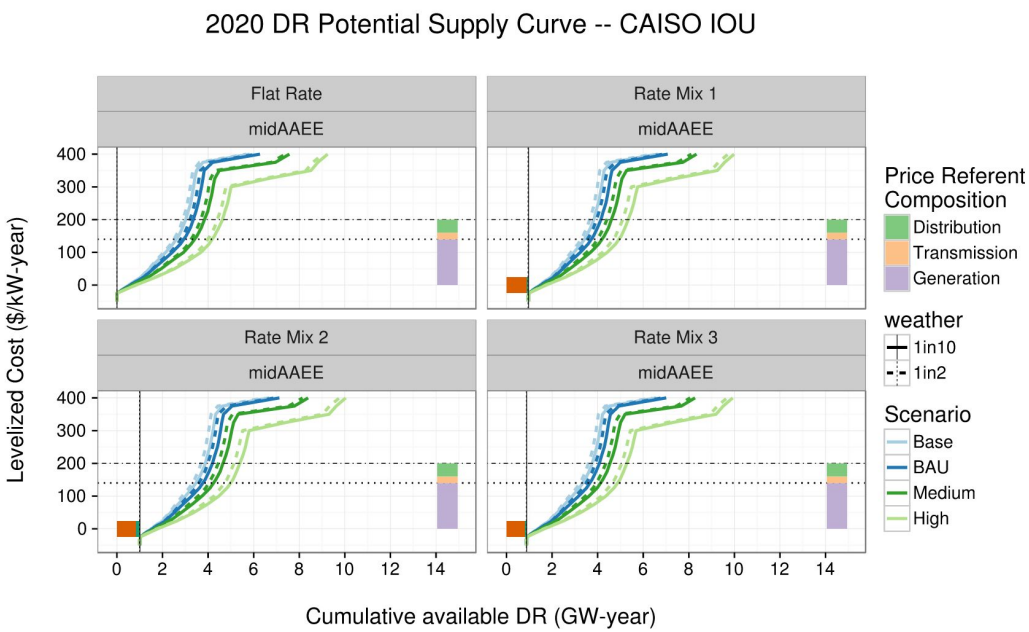
PG&E total: 2.0 GW SCE total: 1.9 GW SDG&E total: 0.24 GW

Total Medium Scenario: 4.2 GW

Total MW:

sector	end_use	tot
com	battery	0
com	bev	0
com	bev_work	0
com	hvac	538
com	lighting	860
com	phev	0
com	phev_work	0
com	refrigeration	36
ind	battery	0
ind	process	1710
ind	pumping	292
res	battery	0
res	bev	79
res	hvac	356
res	phev	324
res	poolpump	0

Systemwide DR by Rate Mix



Residential Rate Mix #1

- PG&E Option #2 as default rate
- SCE Option #3 as an opt-in rate
- PG&E Standard flat rate for customers that opt out of default tariff (used in Phase 1)

Residential Rate Mix #2

- PG&E Option #2 as default rate
- Critical Peak Pricing as an opt-in rate
- PG&E Standard flat rate for customers that opt out of default tariff

Residential Rate Mix #3

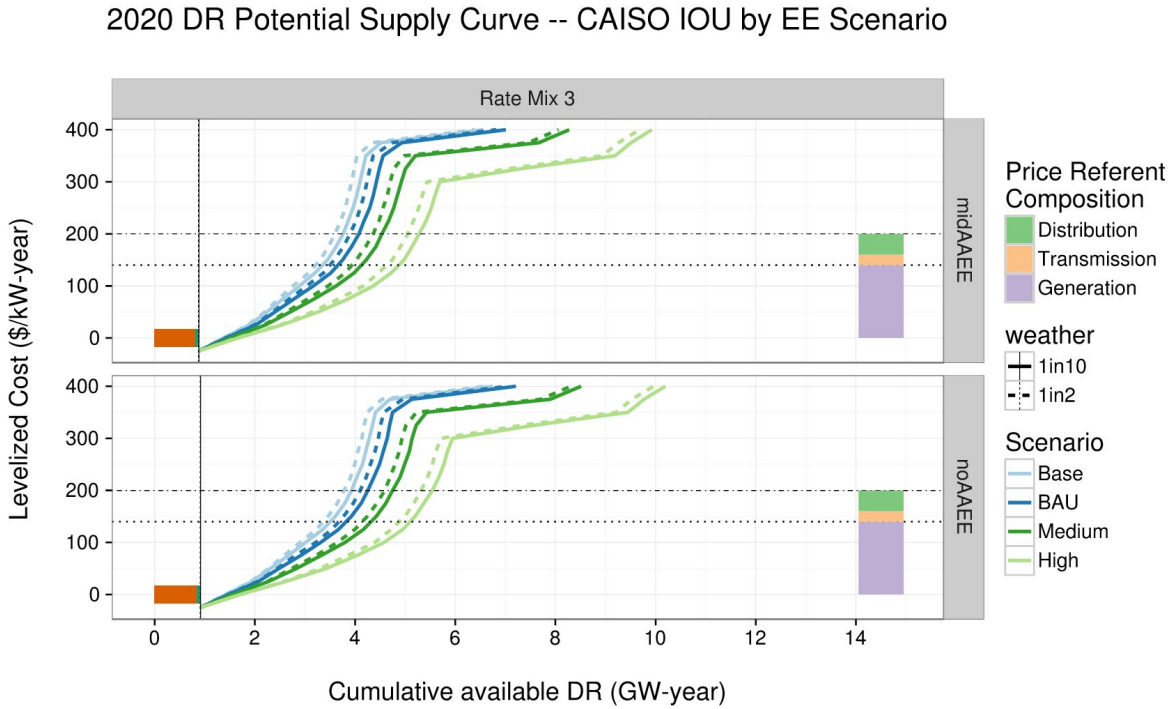
- PG&E Option #2 as the default rate
- PG&E Standard rate for customers that opt out of the default tariff

Small, Medium, Large Commercial & Industrial customers

- For IOU's SMB & C&I customers, we forecasted TOU/CPP impacts for 2020 & 2025 under TOU & CPP tariff structures analyzed in the Christenson report.

- Model predicts more DR with all 3 TOU rate mix options + supply DR, compared to flat rate option
- Study does not estimate administrative costs of running a CPP/TOU program. TOU & CPP program costs are assumed to be approximately zero.

2020 DR Potential (RA) with Mid-AAEE vs. No EE

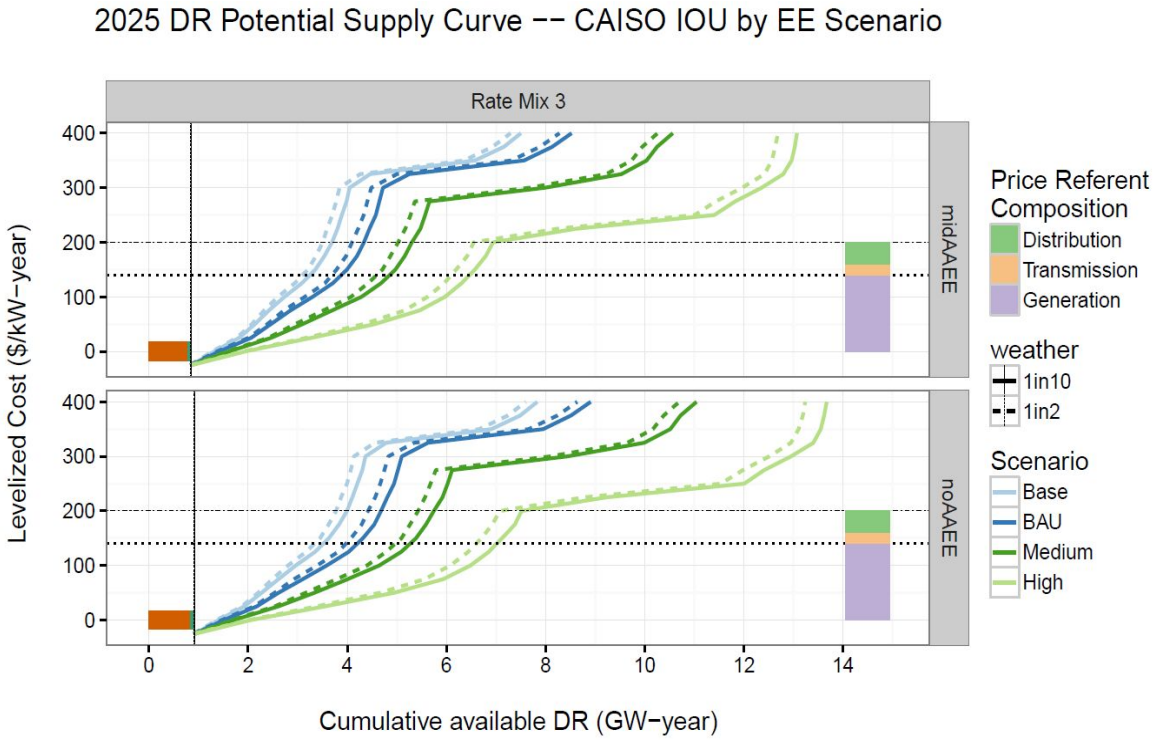


Mid-AAEE, Rate mix 3, 1:2 weather, $200/kW/yr price referent				
Utility	**Base**	**BAU**	**Medium**	**High**
PG&E	1.3	1.5	1.7	2.0
SCE	1.2	1.4	1.6	1.9
SDG&E	0.1	0.1	0.2	0.2
Total	**2.6**	**3.0**	**3.5**	**4.1**

No-AAEE, Rate mix 3, 1:2 weather, $200/kW/yr price referent				
Utility	**Base**	**BAU**	**Medium**	**High**
PG&E	1.4	1.6	1.8	2.2
SCE	1.3	1.5	1.7	2.0
SDG&E	0.1	0.2	0.2	0.2
Total	**2.9**	**3.2**	**3.7**	**4.4**

	Base	**BAU**	**Medium**	**High**
GW Difference: *No AAEE -- MidAAEE*	0.2	0.1	0.2	0.3
% Difference	9%	5%	6%	7%

2025 DR Potential (RA) with Mid-AAEE vs. No EE



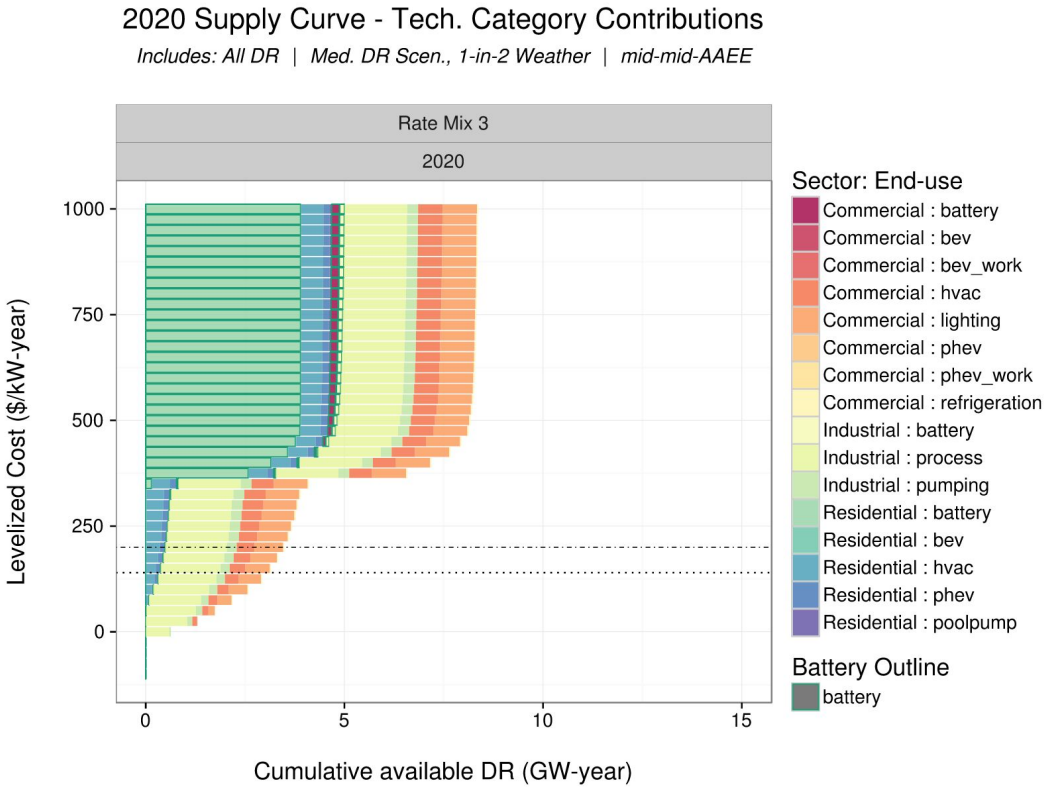
Note: Rounded values in table below.

Mid-AAEE, Rate mix 3, 1:2 weather, $200/kW/yr price referent				
Utility	**Base**	**BAU**	**Medium**	**High**
PG&E	1.3	1.6	2.0	2.8
SCE	1.2	1.5	1.9	2.6
SDG&E	0.1	0.2	0.2	0.3
Total	**2.7**	**3.3**	**4.2**	**5.7**

No-AAEE, Rate mix 3, 1:2 weather, $200/kW/yr price referent				
Utility	**Base**	**BAU**	**Medium**	**High**
PG&E	1.4	1.7	2.2	3.0
SCE	1.3	1.6	2.1	2.8
SDG&E	0.2	0.2	0.3	0.4
Total	**2.9**	**3.5**	**4.5**	**6.2**

	Base	**BAU**	**Medium**	**High**
GW Difference: *No AAEE -- MidAAEE*	0.2	0.3	0.3	0.5
% Difference	8%	8%	8%	8%

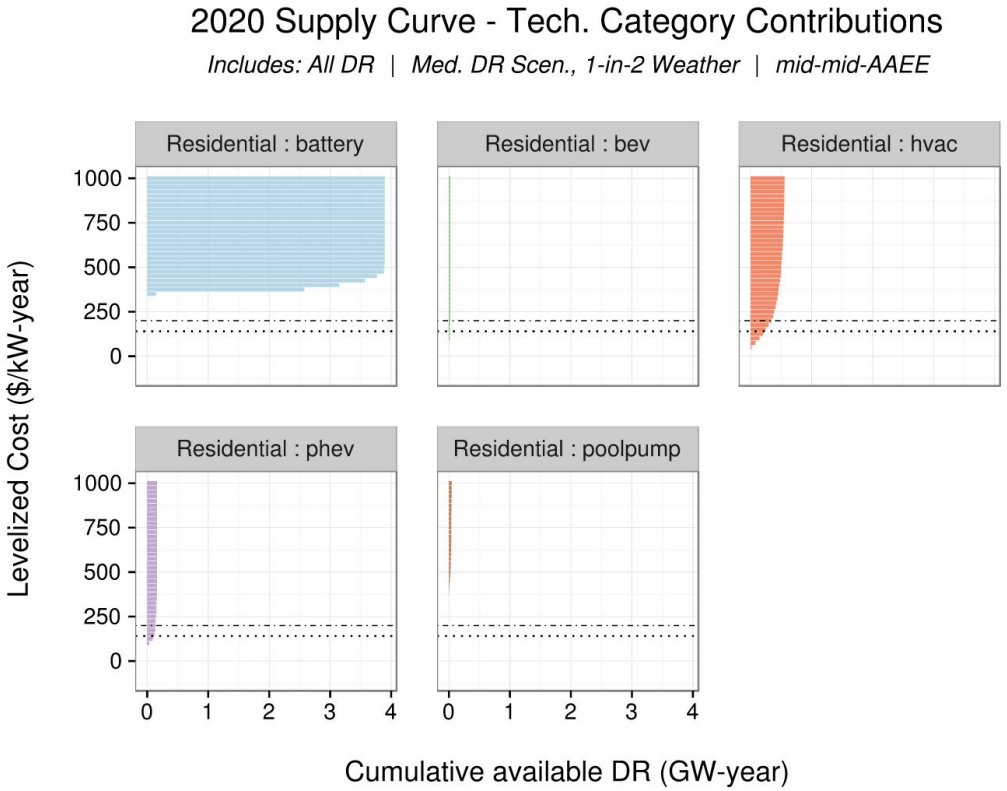
DR Potential Tech Category Contributions - 2020



Note:

- Shows how different technology types contribute to a supply curve.
- The next set of slides breaks out the technology contributions by sector.

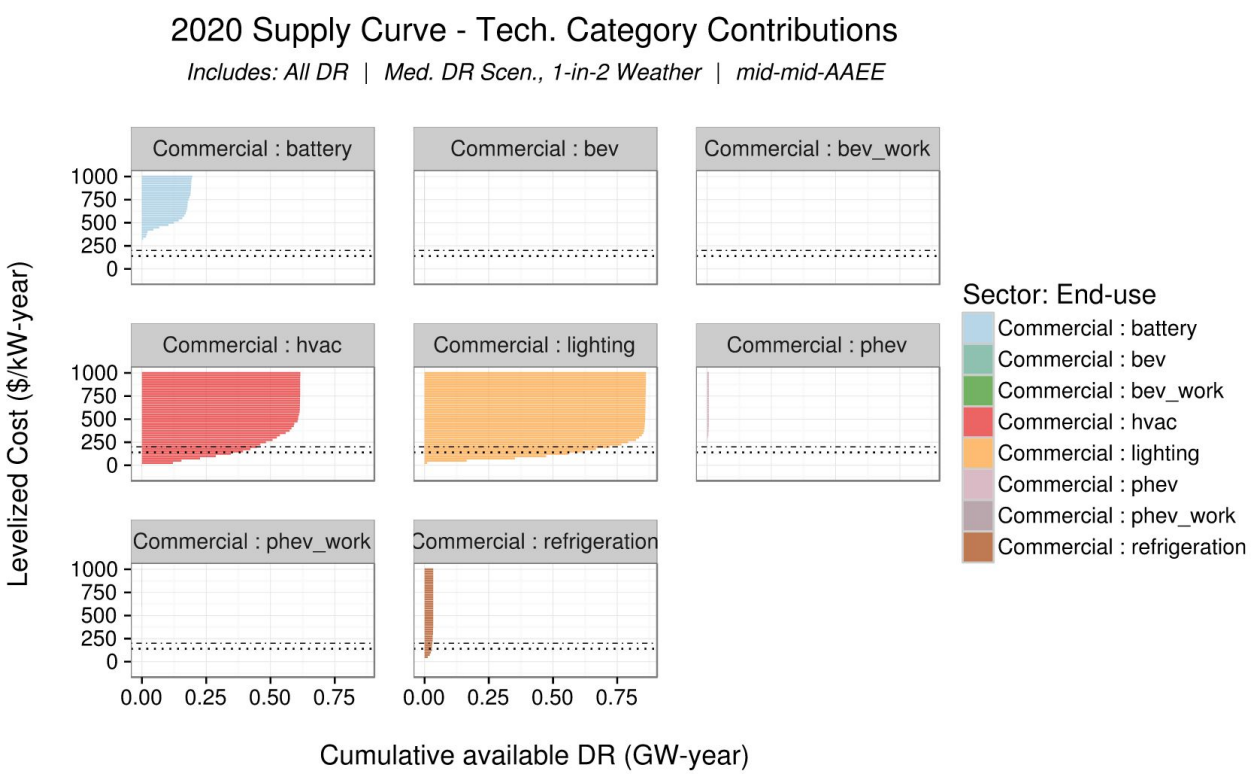
Residential Sector DR Technology

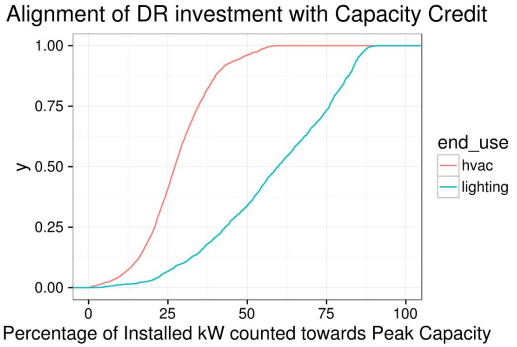


Note:

- Illustrates fleet of possible batteries included in model that are a significant contribution in expanding DR available in 2020, but currently is not cost competitive as batteries are priced at ~$300/kW-yr.

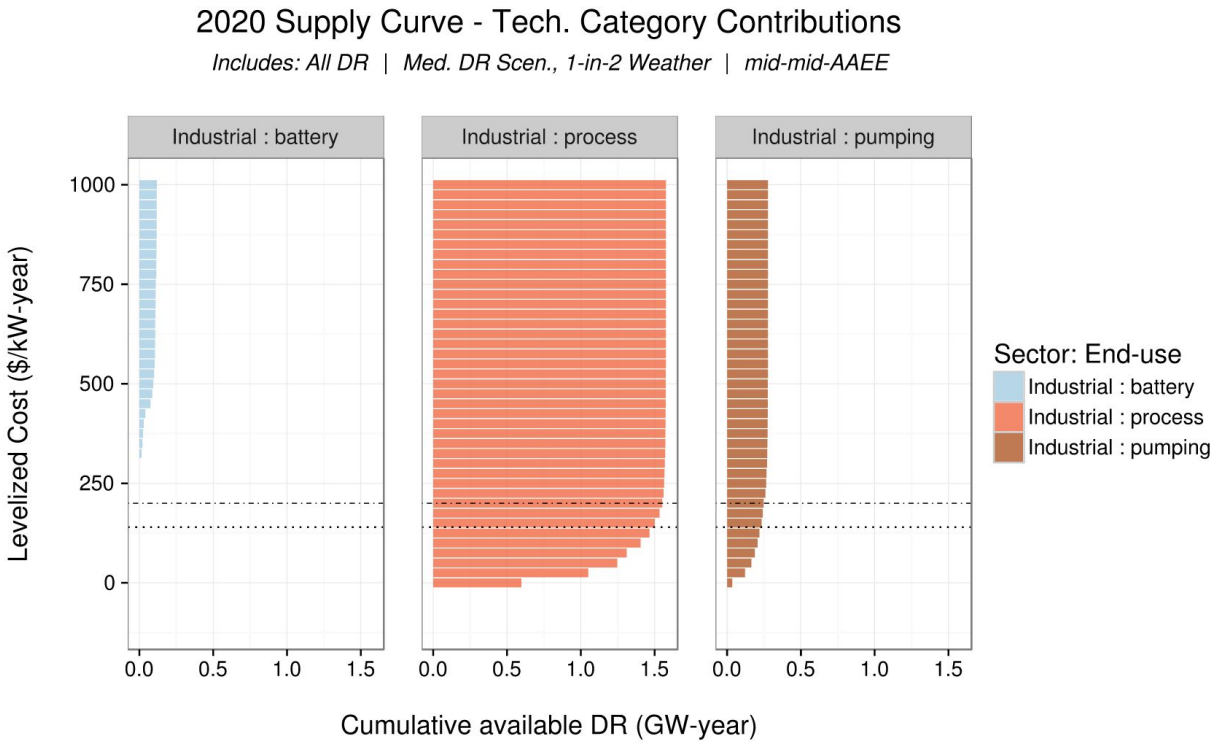
Commercial Sector DR Technology





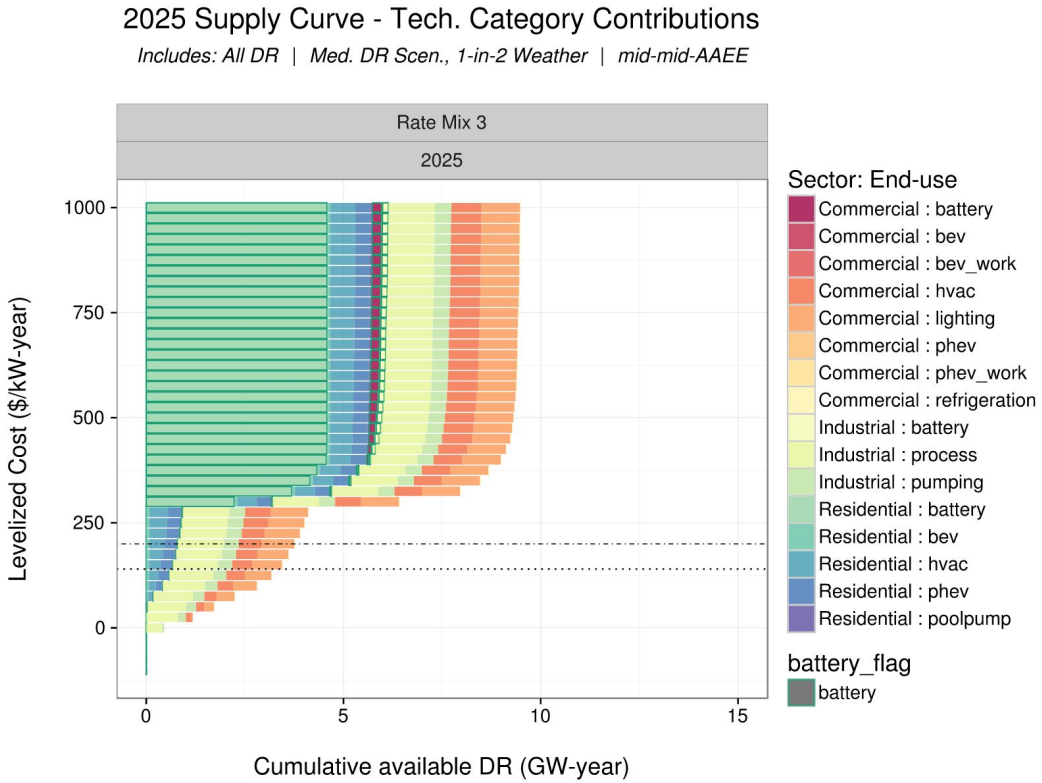
- Lighting DR is well aligned with top 250 hours of future net loads & thus, each lighting kW available to shed typically counts more toward capacity credits compared to HVAC. This explains partly why Lighting DR estimates are higher than HVAC, which goes against conventional wisdom.

Industrial Sector DR Technology



DR Potential Tech Category Contributions

Next set of slides same as previous, but for 2025



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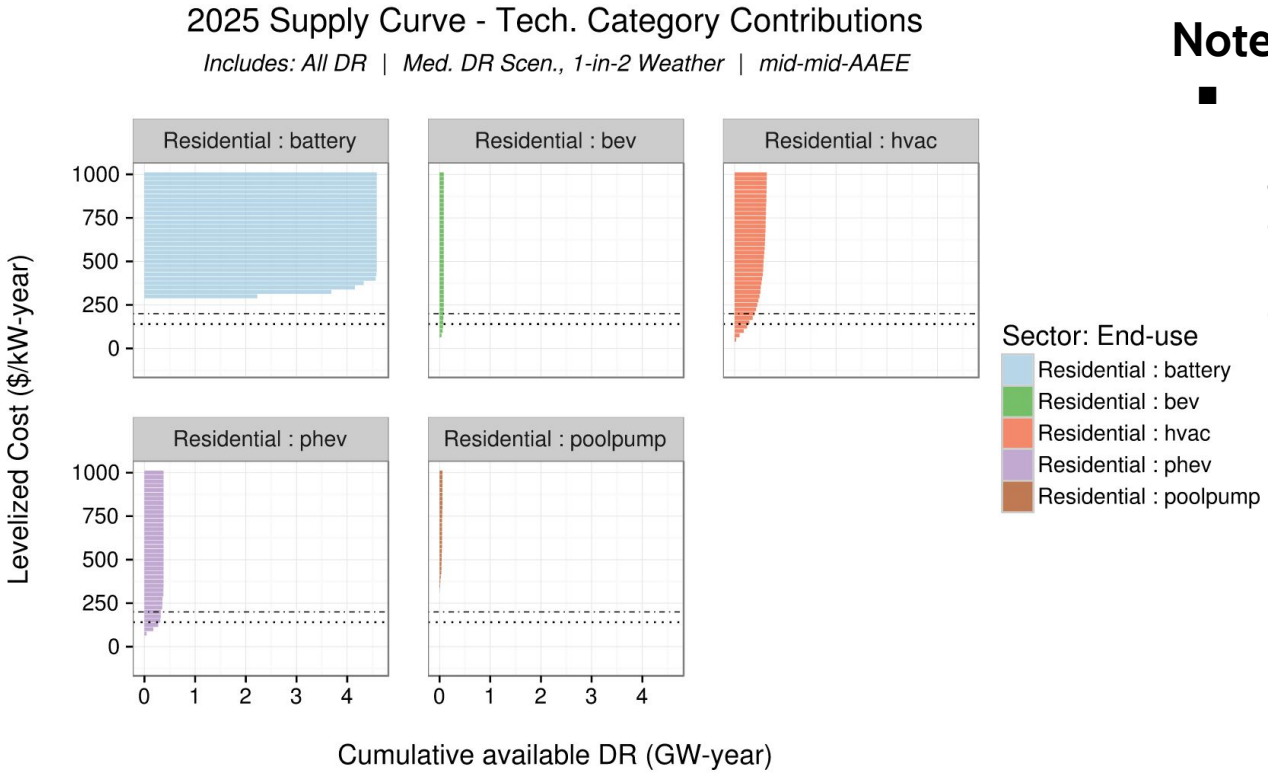
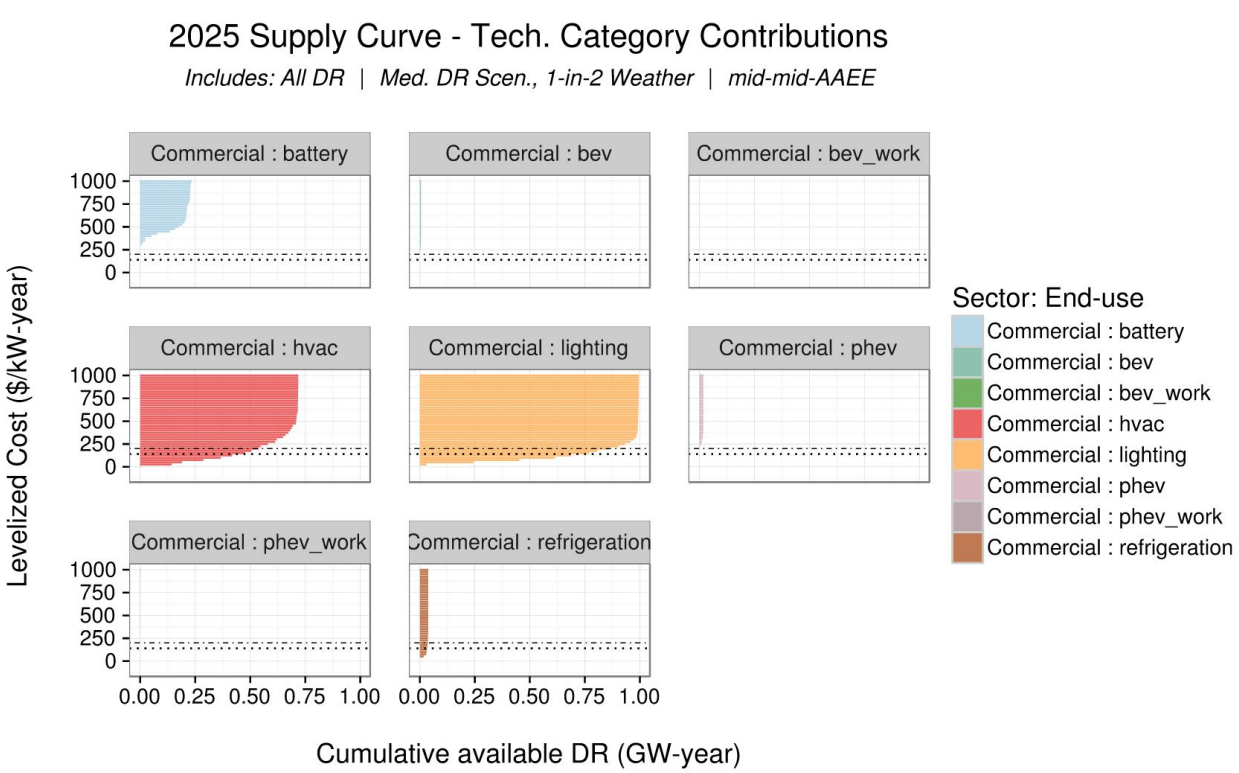
Residential Sector DR Technology

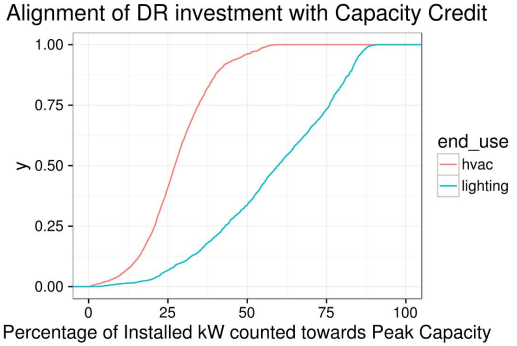


Note:

- Illustrates fleet of possible batteries included in model that are a significant contribution in expanding DR available in 2025, but currently is not cost competitive as batteries are priced at ~$300/kW-yr.

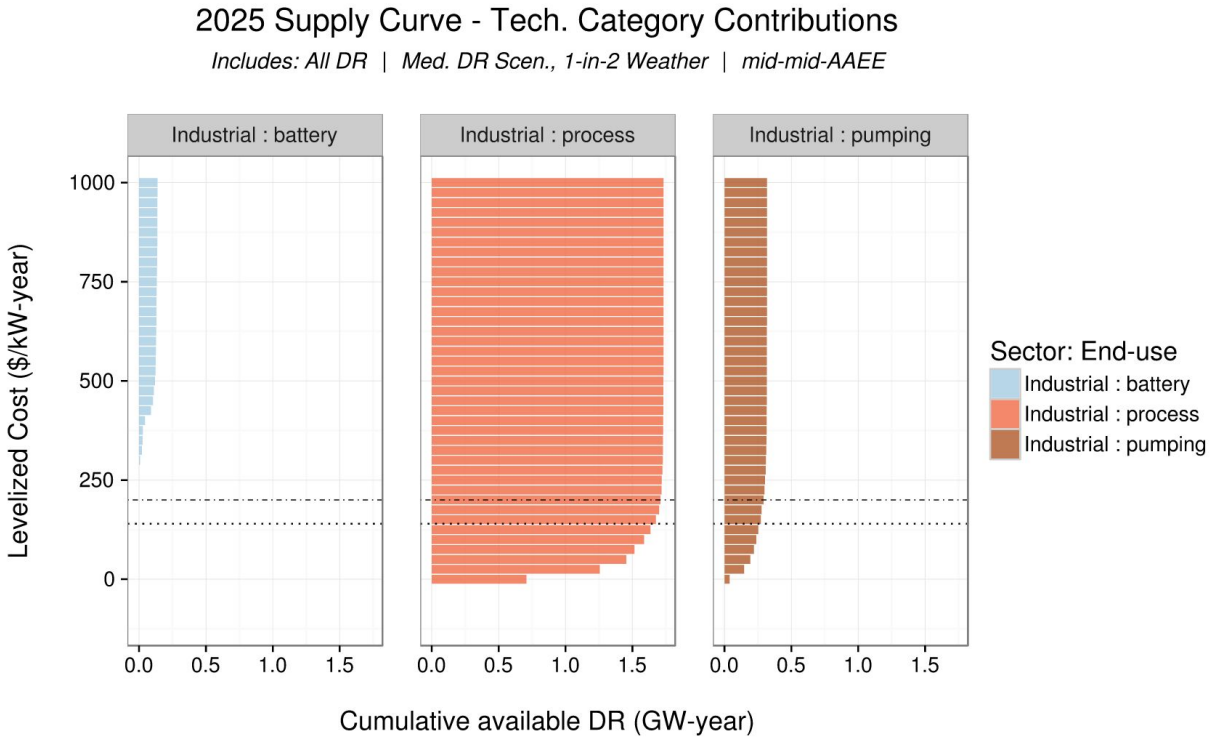
Commercial Sector DR Technology



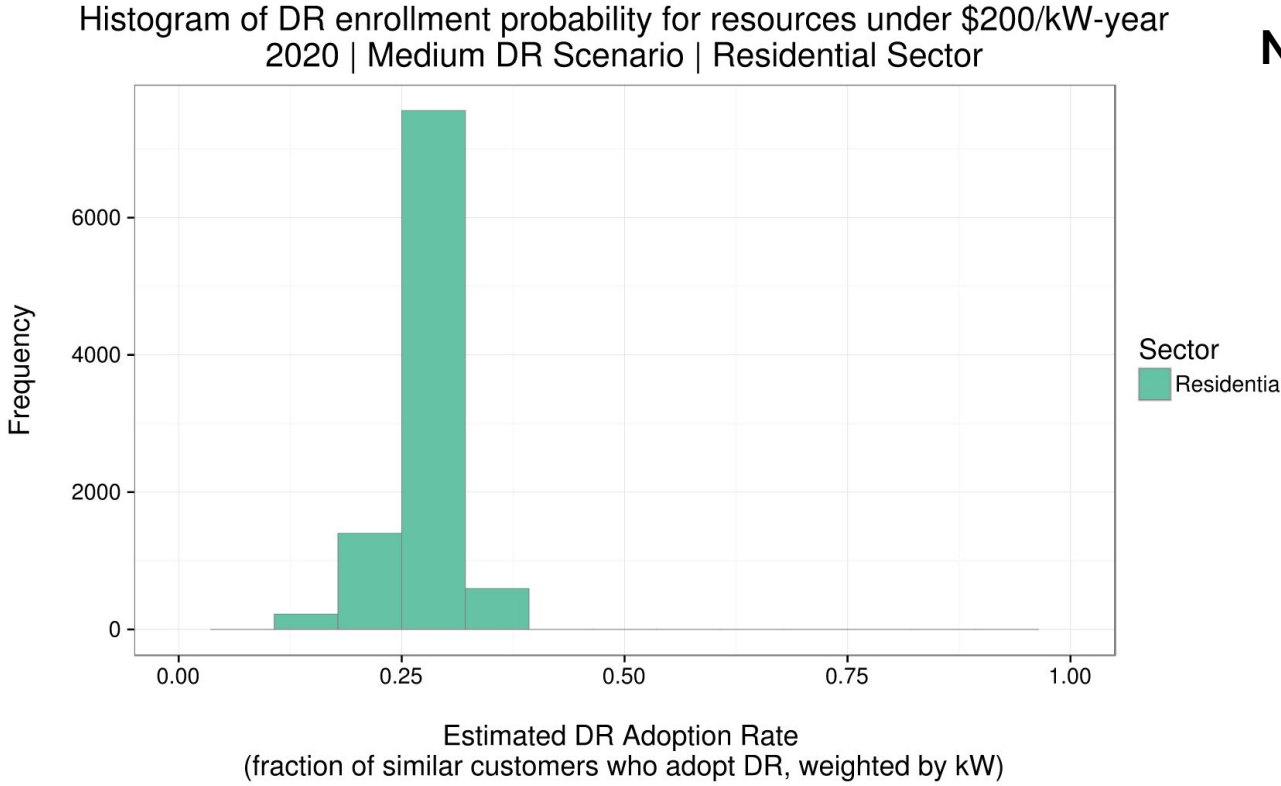


- Lighting DR is well aligned with top 250 hours of future net loads & thus, each lighting kW available to shed typically counts more toward capacity credits compared to HVAC. This explains partly why Lighting DR estimates are higher than HVAC, which goes against conventional wisdom.

Industrial Sector DR Technology



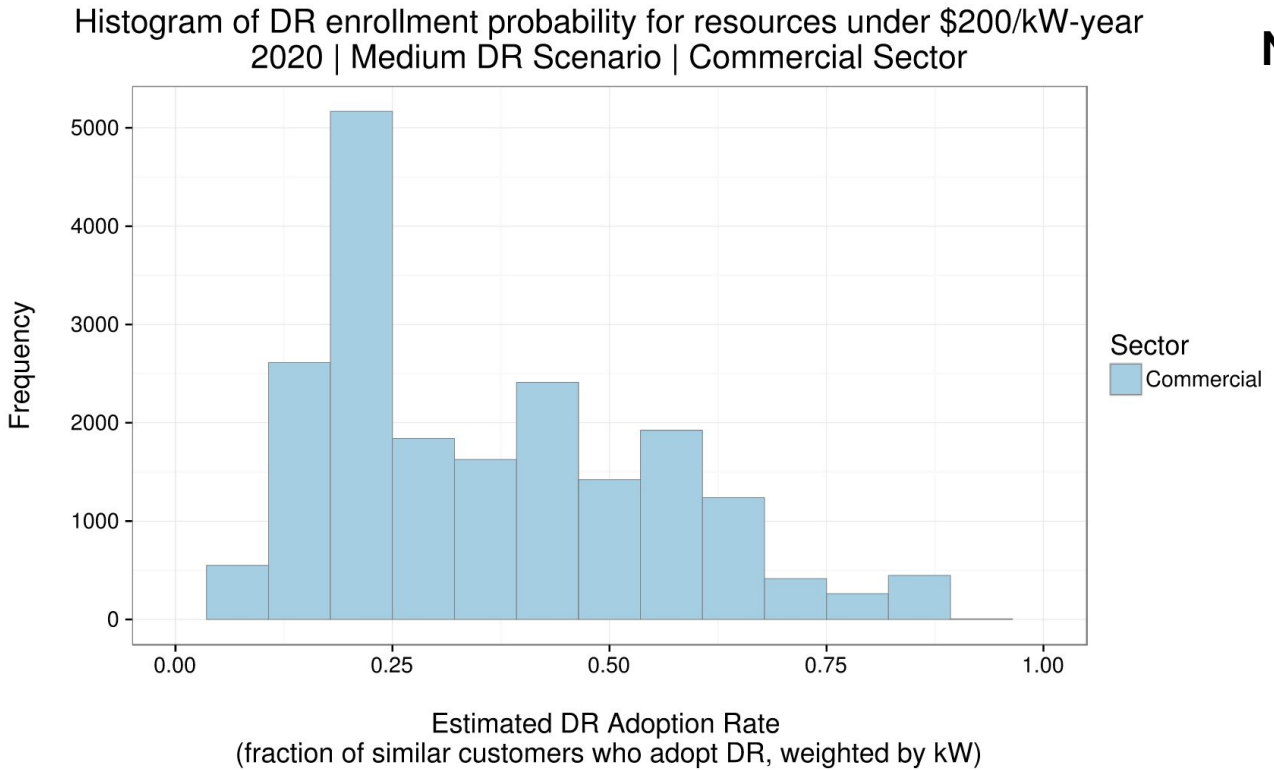
Residential Sector DR Adoption



Note:

- We use parametric estimates of the probability to enroll in DR based on demographic factors & the specifics of an offer (the incentive, etc.).
- These are based on historical participation & projected into the future using scenario adjustments.

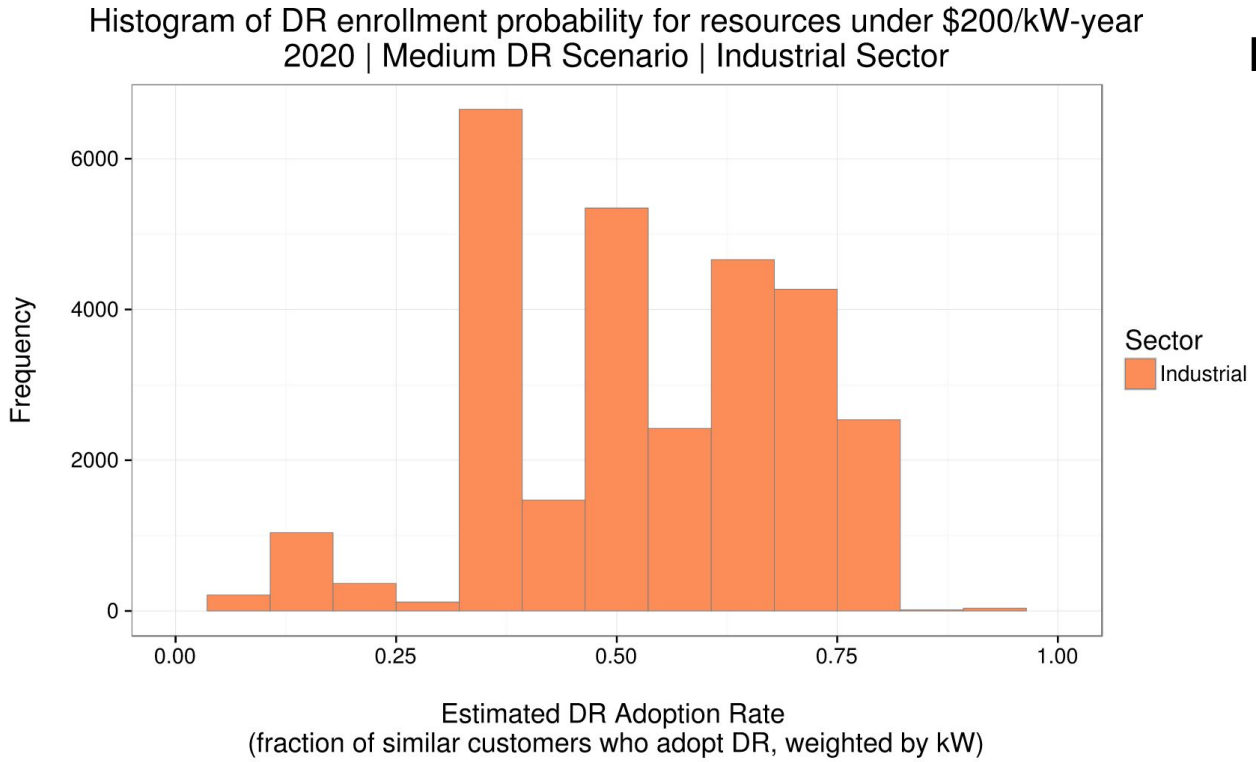
Commercial Sector DR Adoption



Note:

- For small & medium commercial customers, we use same parametric approach as residential.
- For large customers, we improve the estimates using actual 2014 DR participation rate for each cluster as a "non-parametric" baseline & adjust it using the parametric model.

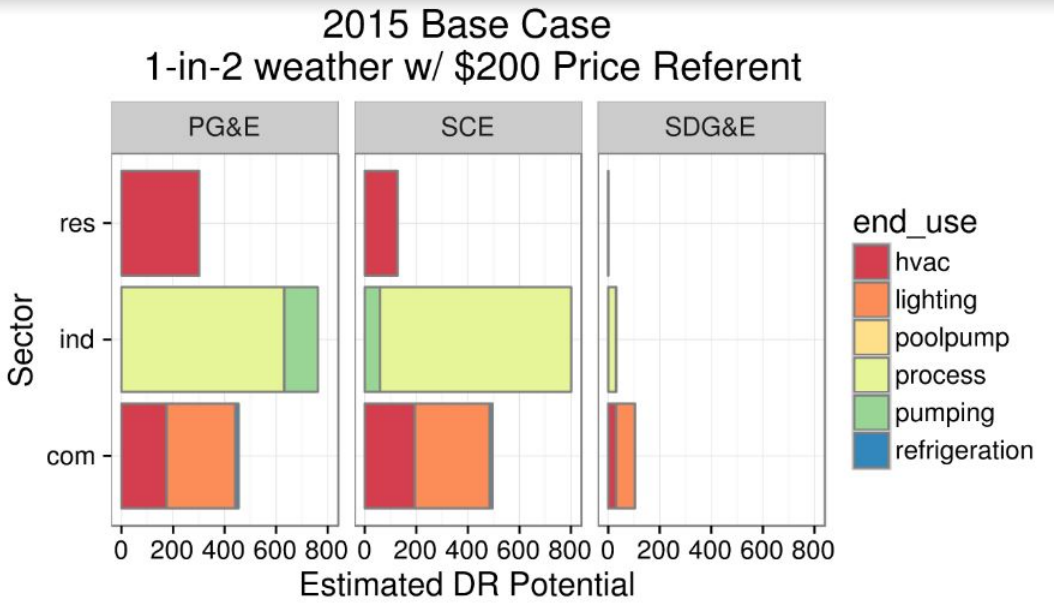
Industrial Sector DR Adoption



Note:

- The same approach for commercial is used for industrial customers, with parametric estimates for small & medium customers & a mixed approach for large customers.

Benchmark to 2015

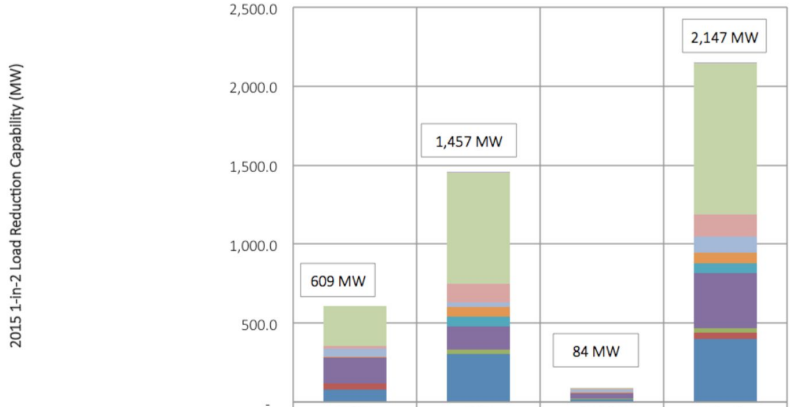


- Model results for 2015 "base" scenario under the Rate mix #3. While basis for measuring utility DR program "pre-bifurcation" is different, this remains useful comparison against scale of programs as **benchmark of model estimates to real-world outcomes.**

Table shows overall totals in sector end-use ---->

Sector and End-use	MW
Commercial : hvac	401
Commercial : lighting	630
Commercial : refrigeration	23
Industrial : process	1403
Industrial : pumping	191
Residential : hvac	428
Total	**3077**

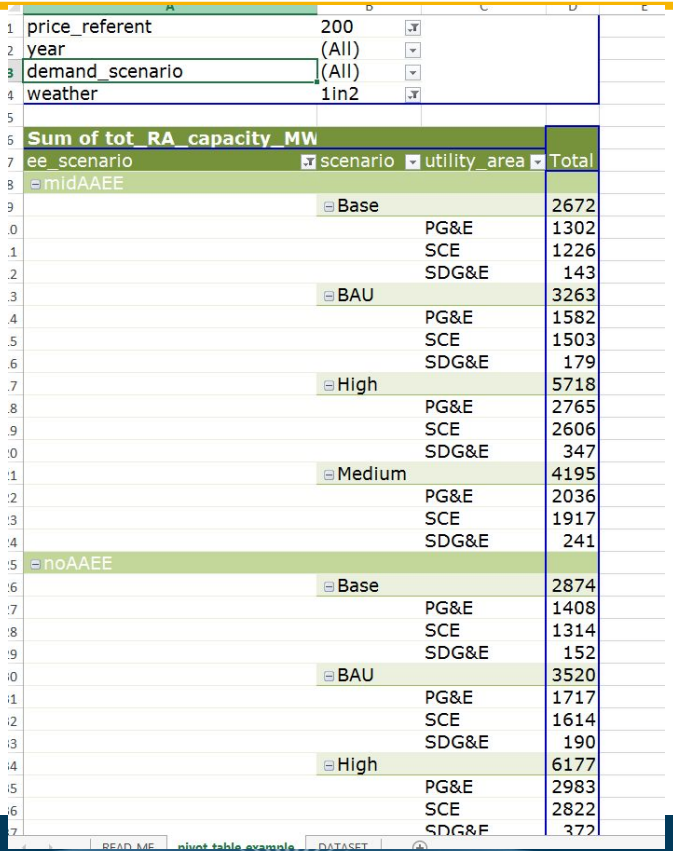
2014 Program Estimates



	PG&E	SCE	SDG&E	Total
Non-Res - Real time pricing		2.5		2.5
Non-Res - Interruptible rates	252.1	707.8	1.0	961.0
Non-Res - Demand bidding	21.0	114.5	2.6	138.1
Non-Res - Critical peak pricing	51.5	29.8	20.9	102.2
Non-Res - Air conditioner load control	2.7	64.3	3.1	70.1
Non-Res - Agricultural pump control		59.4		59.4
Non-Res - Aggregator programs	165.7	147.2	34.7	347.6
Residential - Peak time rebates		27.0	5.3	32.3
Residential - Critical peak pricing	36.9			36.9
Residential - Air conditioner load control	78.9	304.5	17.0	400.3

Figure 9: Total DR resource based on filings for 2015. Source: Utility Monthly reports on interruptible load and demand response programs. Filed with the CPUC (A.11-03-001).

Detailed Data Files & Excel Viewer Template



price_referent	200	
year	(All)	
demand_scenario	(All)	
weather	1in2	

Sum of tot_RA_capacity_MW			
ee_scenario	scenario	utility_area	Total
midAAEE			
	Base		2672
		PG&E	1302
		SCE	1226
		SDG&E	143
	BAU		3263
		PG&E	1582
		SCE	1503
		SDG&E	179
	High		5718
		PG&E	2765
		SCE	2606
		SDG&E	347
	Medium		4195
		PG&E	2036
		SCE	1917
		SDG&E	241
noAAEE			
	Base		2874
		PG&E	1408
		SCE	1314
		SDG&E	152
	BAU		3520
		PG&E	1717
		SCE	1614
		SDG&E	190
	High		6177
		PG&E	2983
		SCE	2822
		SDG&E	372

READ_ME | pivot table example | DATASET

Note:

- Data in "DATASET" tab provides a detailed view on estimated DR resource potential across a range of scenarios & price referent levels.
- These are data used to develop supply curves & other analytic results from the DR-PATH model.
- This data table layout is particularly well-suited for pivot-table analysis (& similar analysis).
- Review the Read_Me tab in Excel Template.

Updated Model Inputs – Details

LBNL-LOAD Module Updates

- Updated customer clusters.
  - Additional load data & new clustering algorithm.
- System load profiles updated to incorporate 2015 IEPR's mid-Growth mid-AAEE scenario & mid-Growth no-AAEE scenario, replacing Phase 1's "frozen efficiency" baseline.
  - Net system load profiles recalculated with mid-AAEE scenario as new baseline.
- Electric vehicle load simulation updated with AMI interval data.

Updated Process for Developing Cluster Load Profiles & Forecasting Baselines to 2025

1. Aggregate sample time series from 2014 to develop cluster-level annual load profiles.
2. Cluster total load profiles are calibrated to match 2015 IEPR's mid-Growth 2014 consumption estimates by IOU & sector.
3. Forecast cluster load profiles to 2020 & 2025 using IEPR's mid-Growth mid-AAEE and no-AAEE forecasts.

1. Summary: Phase 1 Re-Clustering

Sector	Clusters (Quantity)	Customer Count (5th Percentile)	Customer Count (Median)	Customer Count (95th Percentile)	Avg. Number of Time Series per Cluster
Residential	493	1,450	11,148	56,530	201
Commercial	1,402	9	247	2,639	55
Industrial	1,614	4	43	619	15
Other	68	345	831	2,308	23
Total	3,577				

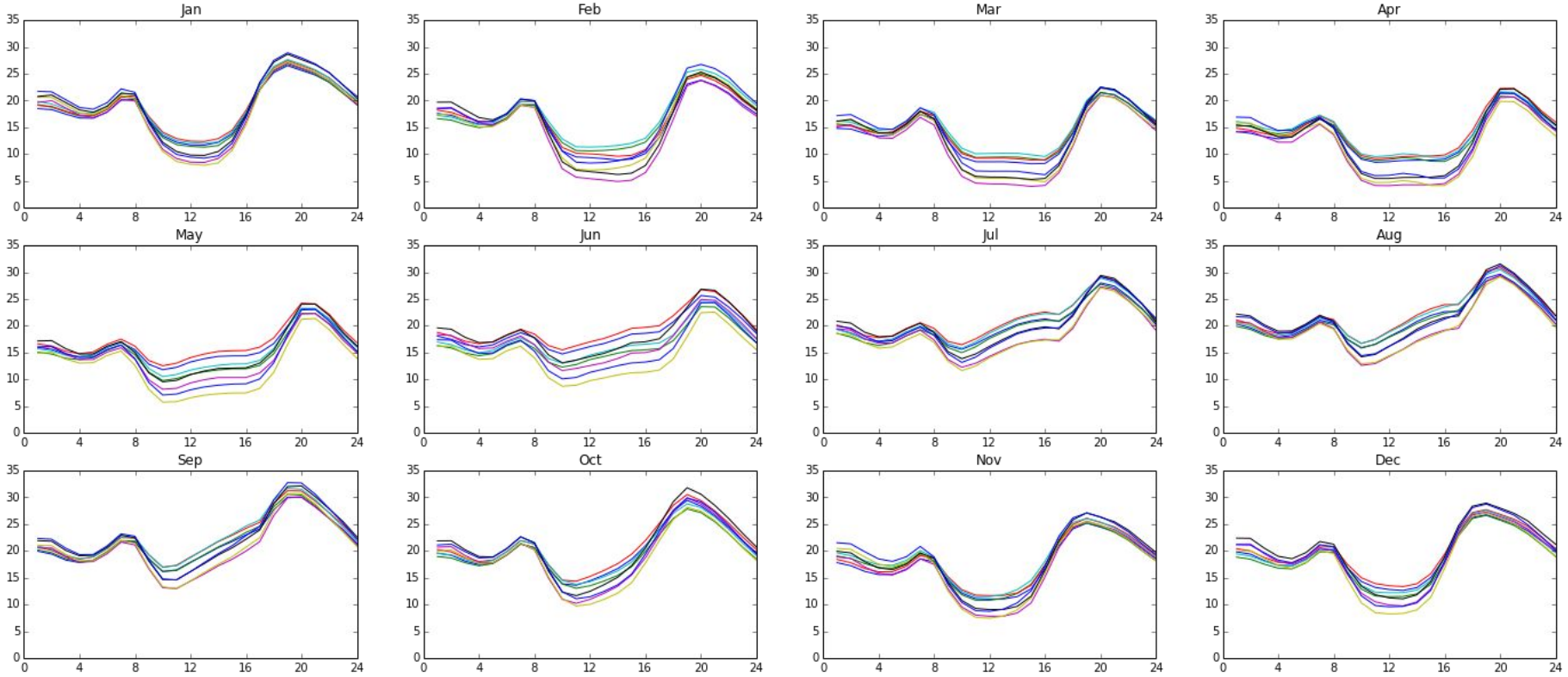
2. Calibrate Profiles to IEPR 2014 Consumption

Utility	Residential (TWh)	Commercial (TWh)	Industrial (TWh)	Other (TWh)	Total (TWh)
PG&E	31.6	36.5	25.5	9.9	103.5
SCE	32.8	39.1	25.6	9.0	106.5
SDG&E	7.7	9.8	1.8	2.2	21.5
Total	72.1	85.4	52.9	21.1	231.5

3. Forecast Incorporating AAEE Impacts

- Forecast cluster time series from 2014 to 2020 & 2025, calibrated to 2015 IEPR mid-Demand mid-AAEE & no-AAEE scenarios.
- Mid AAEE scenario reduces system gross & net loads, which reduces overall need for capacity RA.

Forecast Results – System Net Load for 8 Scenarios
(Gross Demand – Solar & Wind Generation)



Summary: DRPATH & Economic Valuation Module Updates

- Planning reserve margin of 15% was removed from benefits to avoid double-counting DR's capacity contribution
- Costs for electric vehicle enabling technology were updated to reflect price decreases
- Additional TOU & CPP rate cases incorporated into analysis

TOU & CPP Rate Scenarios

Residential Rate Mix #1	• PG&E Option #2 as default rate • SCE Option #3 as an opt-in rate • PG&E Standard flat rate for customers that opt out of default tariff (used in Phase 1)
Residential Rate Mix #2	• PG&E Option #2 as default rate • Critical Peak Pricing as an opt-in rate • PG&E Standard flat rate for customers that opt out of default tariff
Residential Rate Mix #3	• PG&E Option #2 as the default rate • PG&E Standard rate for customers that opt out of the default tariff
Small, Medium, Large Commercial & Industrial customers	• For IOU's SMB & C&I customers, we forecasted TOU/CPP impacts for 2020 & 2025 under TOU & CPP tariff structures analyzed in the Christenson report.

Note:

- Phase 1 update now includes three TOU rate mixes, whereas April 1st original results only included "Rate mix #3"